

Industry Overview

With the nation's second-largest aerospace economy, Colorado is an aerospace leader and a premier location for companies conducting aerospace-related activities. The state has a distinguished history of groundbreaking space exploration and travel, major space missions and projects, and aerospace research and development. Colorado is a top aerospace state supported by the combination of military presence, renowned research laboratories and universities, natural attributes, and a dynamic business environment. Eight of the nation's top aerospace contractors have significant operations in the state. Colorado hosts major U.S. Department of Defense (DoD) facilities and the National Aeronautics and Space Administration (NASA) research and development activities, and the state's universities are among the world's best for aerospace engineering.



Colorado's aerospace industry includes a broad range of companies, products, and systems for commercial, military, and civil space applications. Colorado's aerospace companies research, develop, design, and manufacture guided missiles, spacecraft, satellites and communications equipment, as well as navigation and detection instruments. Colorado companies also produce planetary spacecraft and launch systems and provide mission support. The state's companies and public agencies have achieved some of the most innovative advancements in space exploration technology in recent history and are leading the nation's major commercial, civil, and military space missions and projects. Colorado's unique convergence of aerospace and other high-tech industries such as cleantech, cybersecurity, and information technology, provides further opportunities for innovation, collaboration, and growth.

Colorado's aerospace industry contributes significantly to the state's economic output. Colorado is home to 180 businesses classified as aerospace companies, and more than 500 companies and suppliers providing space-related products and services. Direct employment in the aerospace cluster totals 26,620 private sector workers and approximately 28,810 military personnel. Aerospace employment increased for the third-consecutive year in 2017 and grew at its fastest pace since 2007, rising 4.7 percent between 2016 and 2017. In total, the 55,430 workers in the aerospace cluster support an additional 135,450 workers in all industries throughout Colorado, bringing direct and indirect employment supported by the aerospace cluster to 190,880 workers. In total, Colorado's aerospace industry generates \$15.4 billion in total output each year.¹

The majority of Colorado's key aerospace businesses, facilities, and research institutions are located in the nine-county Metro Denver and Northern Colorado region.² The region's 21,090 private sector aerospace workers represent 79.2 percent of all aerospace workers in Colorado. The region's 130 aerospace companies represent 73.3 percent of the state's total companies in the cluster.

¹ Calculated by Development Research Partners, based on multipliers for Colorado from the U.S. Department of Commerce, Bureau of Economic Analysis, Regional Input-Output Modeling System (RIMS II), 2007 U.S. Benchmark I-O data and 2013 Regional Data.

² The nine-county region is comprised of two principal areas, Metro Denver and Northern Colorado. Metro Denver consists of Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, and Jefferson counties. Northern Colorado consists of Larimer and Weld counties.

AEROSPACE: Colorado Industry Cluster Profile

Private Aerospace Economic Profile

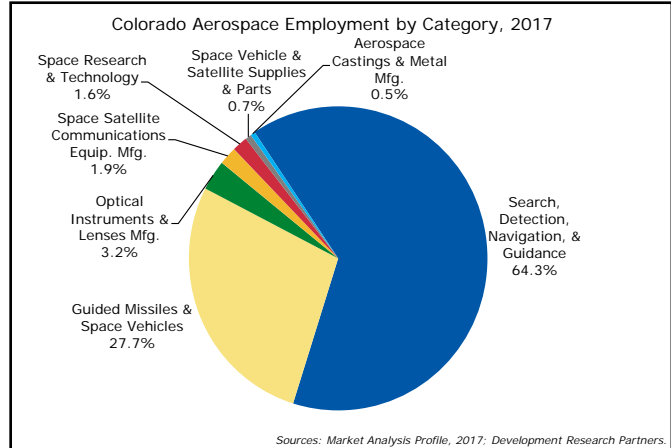
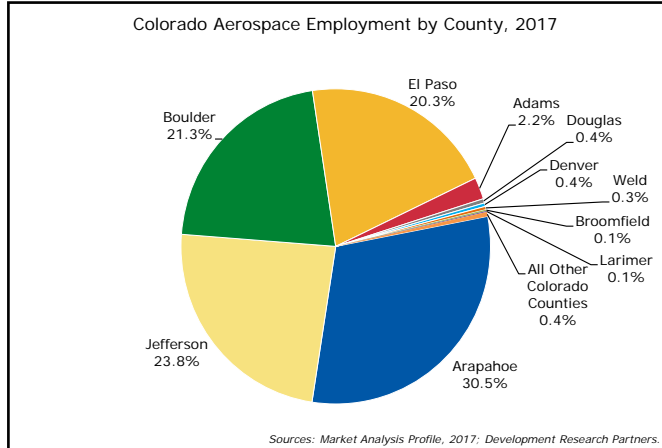
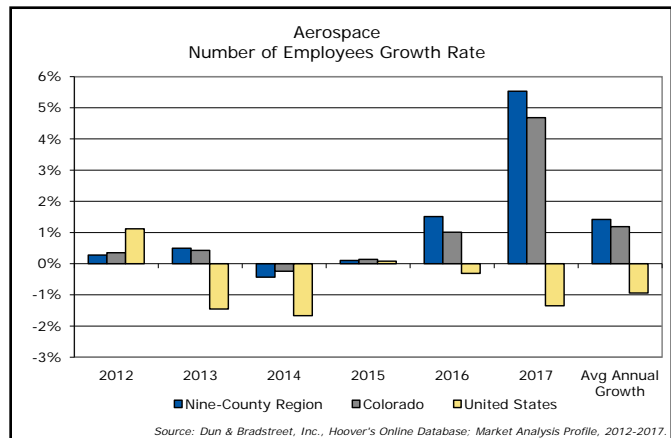
The aerospace cluster consists of 19, six-digit North American Industry Classification System (NAICS) codes including search, detection, and navigation instrument manufacturing; guided missile and space vehicle manufacturing; satellite telecommunications; and research and development.

Rankings¹

Nine-County Region	
Aerospace direct employment concentration rank	1st
Aerospace direct employment rank	1st
Colorado	
Aerospace direct employment concentration rank	1st
Aerospace direct employment rank	2nd

Aerospace Employment and Company Profile, 2017			
	Nine-County Region	Colorado	United States
Direct employment, 2017	21,090	26,620	346,030
Number of direct companies, 2017	130	180	5,360
One-year direct employment growth, 2016-2017	5.5%	4.7%	-1.3%
Five-year direct employment growth, 2012-2017	7.3%	6.1%	-4.6%
Avg. annual direct employment growth, 2012-2017	1.4%	1.2%	-0.9%
Direct employment concentration	0.9%	0.8%	0.2%

Sources: Dun & Bradstreet, Inc., Hoover's Online Database; Market Analysis Profile, 2012-2017; Development Research Partners.



¹ Direct employment rank based on the number of employees in the industry cluster in a state or region. Employment concentration rank based on the direct cluster employment in a state or region expressed as a percent of total employment in all industries in the same state or region. Rankings are for the 50 largest metropolitan statistical areas (MSAs) and 50 largest states. No multiplier effects are included. 1st = highest for both rankings.

AEROSPACE: Colorado Industry Cluster Profile

Major Aerospace Contractors

Eight of the country's major space contractors have a significant presence in Colorado. These companies support the U.S. Department of Defense (DoD) to procure, place, and manage national space assets for the military. They also provide manned and unmanned spacecraft, instrumentation, and ground control services for the National Aeronautics and Space Administration (NASA) and other agencies.



Based in Boulder, **Ball Aerospace & Technologies Corp.** provides support of space and Earth science, space exploration, national security and intelligence, and tactical programs. Ball Aerospace creates innovative space solutions, enables more accurate weather forecasts, drives insightful observations of our planet, and delivers actionable data and intelligence.

www.ballaerospace.com



The Boeing Company has several locations throughout Colorado with the largest concentrations in Arapahoe County and Colorado Springs. Core business activities include: Jeppesen, a subsidiary of Boeing that provides navigational information to commercial, business, and military aviation; strategic missile defense systems; space and intelligence and Global Positioning System (GPS) support; and Boeing military aircraft support at Fort Carson.

www.boeing.com



Harris Corporation is a leading technology innovator, solving customers' toughest mission-critical challenges by providing solutions that connect, inform, and protect. The company has offices in 10 Colorado locations, including Broomfield and Colorado Springs. Colorado is a key location for the **Space and Intelligence Systems** segment, which provides complete solutions encompassing advanced sensors and payloads, processing systems, and analytics for global situational awareness, space superiority missions, and Earth insights. www.harris.com



Lockheed Martin develops products ranging from human space flight systems and navigation, meteorological, and communications satellites to ground station and missile defense systems. The **Space Systems Company** unit headquartered in Jefferson County designs, develops, tests, and manufactures advanced technology systems for its government, international, and commercial customers. www.lockheedmartin.com



Northrop Grumman provides a range of products and services related to systems integration, missile systems and national security technologies, defense electronics, marine and space systems, and battle management. The company also works with advanced aircraft, unmanned aircraft vehicles, naval vessels, and space technology. www.northropgrumman.com



Raytheon Company, with the majority of its employees located in Aurora, manages spacecraft missions and analyzes post-launch data through a variety of technologies including radio frequency, GPS, communications and intelligence, and electro-optical/infrared.

www.raytheon.com



Sierra Nevada Corporation's (SNC) Space Systems business area, located in Louisville, develops subsystems and components for space applications, is a prime contractor for small satellites, and owns and operates the *Dream Chaser*[®] spacecraft. The company's two Centennial divisions—the **Intelligence, Surveillance, and Reconnaissance** and the **Information and Sensor Solutions**—provide products and services for a variety of airborne systems. The company has a growing presence in Colorado Springs. www.sncorp.com



United Launch Alliance (ULA) With more than a century of combined heritage, ULA is the nation's most experienced and reliable launch service provider. ULA employs nearly half of its workforce at its Centennial headquarters. ULA's program management, engineering and mission support functions are concentrated in Colorado. This includes development of ULA's new Vulcan Centaur rocket. In 2018, ULA will begin flights of its Atlas V rocket carrying Boeing's Starliner capsule in support of NASA's Commercial Crew program which will return astronauts to space from U.S. soil. www.ulalaunch.com

Additional Major Private Aerospace Companies

- Braxton Technologies
www.braxtontech.com
- Cobham
www.cobham.com
- Honeywell International
www.honeywell.com
- IHS Markit Aerospace, Defense & Security
www.ihs.com
- Intrex Aerospace
www.intrexcorp.com
- Maxar Technologies (formerly DigitalGlobe)
www.digitalglobe.com
- Merrick & Company
www.merrick.com
- Research Electro-Optics, Inc.
www.reoinc.com
- Rocky Mountain Instrument Company
www.rmico.com
- Science Applications International Corp.
www.saic.com
- SEAKR Engineering, Inc.
www.seakr.com
- Special Aerospace Services
www.specialaerospaceservices.com
- Surrey Satellite Technology US LLC
www.sst-us.com
- Trimble
www.trimble.com
- UP Aerospace Inc.
www.upaerospace.com
- Vectrus
www.vectrus.com

Military Aerospace Profile

Colorado is the U.S. center for military space. The state is home to a diverse mix of U.S. Department of Defense (DoD) military installations and major command centers that foster important synergies between private aerospace companies and government entities. The state is also a national hub for cybersecurity and is home to the National Cybersecurity Center in Colorado Springs. The state's military installations provide an annual economic impact of \$27 billion to Colorado's economy and employ more than 170,000 military and defense-related civilian personnel—or 5.2 percent of the state's workforce. Additionally, 7.5 percent of Colorado's labor income is derived from DoD employment and 6.5 percent of the state's Gross State Product is DoD-related.

- **Buckley Air Force Base** in Aurora is home to the 460th Space Wing and supports more than 83 tenant organizations that represent all branches of the military. Tenants are located both on and off the base. The base is also home to the Aerospace Data Facility-Colorado, one of the nation's three satellite ground stations operated by the National Reconnaissance Office. Buckley is home to the only space-based missile warning system in the nation. The base also hosts the Colorado Air National Guard 120th Fighter Squadron and its F-16C fighters.
- **Air Force Bases** in Colorado Springs include Peterson Air Force Base, Cheyenne Mountain Air Force Station, and Schriever Air Force Base.
 - **Peterson Air Force Base** is the home of the 21st Space Wing (SW) as well as the North American Aerospace Defense Command (NORAD), the U.S. Northern Command (USNORTHCOM), Air Force Space Command (AFSPC), U.S. Army Space and Missile Defense Command/U.S. Army Forces Strategic Command (SMDC/ARSTRAT), the 302nd Airlift Wing, as well as a number of other smaller tenant units. The 21st SW is responsible for worldwide missile warning and space control.
 - **Cheyenne Mountain Air Force Station** is owned and operated by Air Force Space Command. It hosts the NORAD and USNORTHCOM Alternate Command Center and other national security activities.
 - **Schriever Air Force Base** is the home of the 50th SW as well as the Space Innovation and Development Center (SIDC), the 310th SW, the Missile Defense Integration and Operations Center (MDIOC), the Joint Functional Component Command for Integrated Missile Defense (JFCC-IMD), and numerous tenant organizations. The 50th SW provides space combat capability through command, control, operations, and support of communication, navigation, warning, surveillance, and weather satellite weapons systems.
- The **U.S. Air Force Academy** in Colorado Springs was established in 1954 as an accredited college to educate officers in the U.S. Air Force. The 10th Air Base Wing is the host wing for the Air Force Academy and provides base-level support activities including medical, engineering, base logistics, fire response services, communications, security, and other key support for more than 25,000 military and

AEROSPACE: Colorado Industry Cluster Profile

civilian personnel. The Academy offers increasingly diverse interdisciplinary programs that encompass more than 20 research centers and institutes. Further, the Academy's premier science, technology, engineering, and mathematics programs are distinguished by the college's partnership with the Institute for National Security Studies.

Defense and Aerospace-Related Personnel Profile, 2017

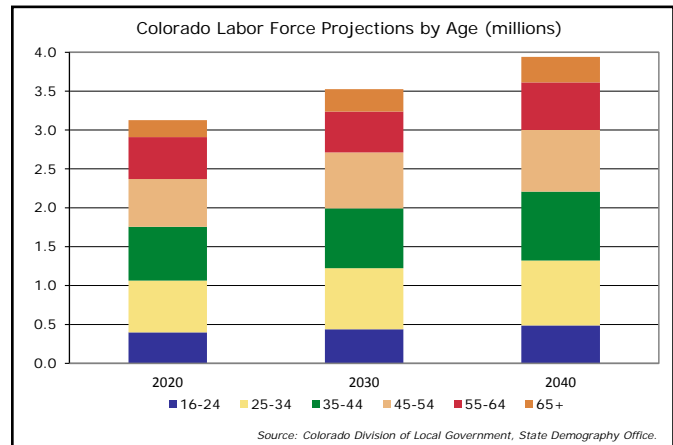
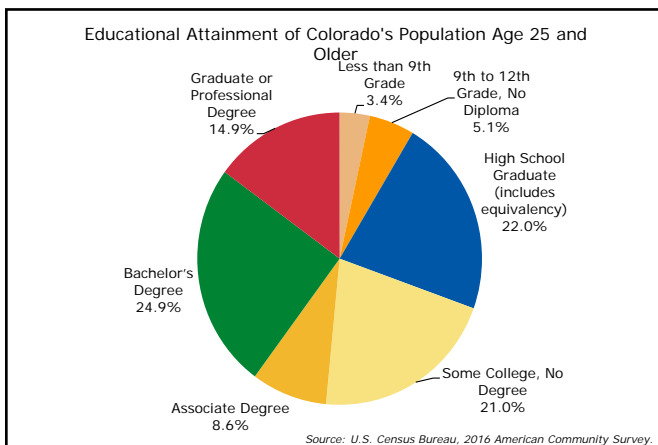
<i>Government Installation</i>	<i>Personnel</i>
Buckley Air Force Base	9,500
Peterson Complex*	8,150
U.S. Air Force Academy	7,270
Schriever Air Force Base	3,890
Total Employment	28,810

*Peterson Complex total includes personnel at Peterson Air Force Base and Cheyenne Mountain Air Force Station (including NORAD, USNORTHCOM, AFSPC, and SMDC/ARSTRAT).

Private Aerospace Workforce Profile

Colorado employers can draw from a large, young, and highly educated workforce.

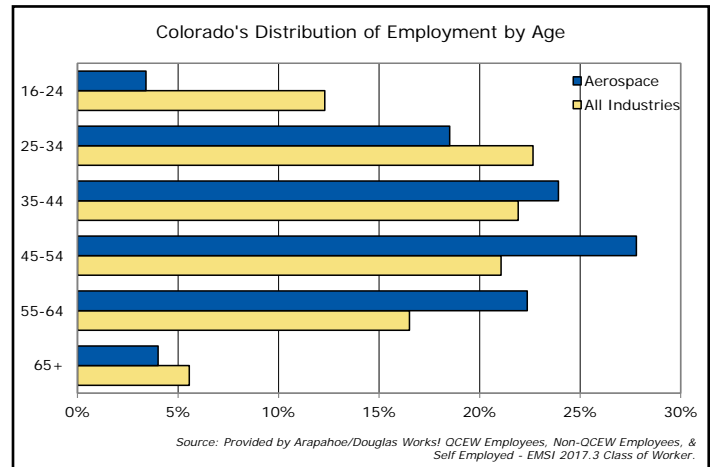
- Colorado has the nation's second-most highly educated workforce as measured by residents with a bachelor's degree or higher.
- 39.9 percent of Colorado adults are college graduates and 91.4 percent have graduated from high school.
- Nearly half of the state's 5.6 million residents are under the age of 35.
- The state's population is expected to grow 31.6 percent from 2020 to 2040, driving a 26 percent increase in the state's labor force over the same period.



Private Aerospace Workforce Profile

Colorado's aerospace cluster has a larger share of employees that are between the ages of 35 and 64 years old (74.1 percent), compared with the age distribution across all industries in the state (59.5 percent). Specifically, the largest share of workers in the aerospace cluster are between the ages of 45 and 54.

The Occupation & Salary Profile below includes the 10 largest aerospace occupations in the state. For these 10 largest occupations, the chart details the total number of workers employed in that occupation across all industries, the number of available applicants that would like to be working in that occupation, the number of recent graduates that are qualified for that occupation, and the median and sample percentile annual salaries.



Wages

Wages in the cluster are among the highest across all industry clusters. The 2016 average annual salary was \$131,200, compared with \$107,240 nationwide, or 22.3 percent more than the national average. Colorado's aerospace cluster payroll exceeded \$3.3 billion in 2016.

Colorado Aerospace Occupation & Salary Profile, 2017

10 Largest Aerospace Occupations in Colorado	Total Working Across All Industries (2017)	Number of Available Applicants (2017)	Number of Graduates (2016)	Median Salary	10th Percentile Salary	25th Percentile Salary	75th Percentile Salary	90th Percentile Salary
1. Business operations specialists, all other	42,109	1,035	21	\$73,904	\$41,931	\$54,939	\$97,753	\$125,027
2. Software developers, systems software	14,350	353	2,157	\$112,874	\$76,627	\$91,591	\$136,774	\$165,462
3. Biological technicians	2,918	72	0	\$44,283	\$29,286	\$34,757	\$57,616	\$70,158
4. Aerospace engineers	2,457	60	261	\$119,870	\$68,619	\$84,427	\$158,538	\$200,450
5. Software developers, applications	26,987	663	1,977	\$103,156	\$63,893	\$80,228	\$126,837	\$154,305
6. Mechanical engineers	5,661	139	930	\$86,236	\$56,440	\$69,475	\$114,212	\$151,552
7. Electronics engineers, except computer	6,029	148	531	\$95,711	\$66,325	\$76,879	\$124,184	\$154,229
8. General & operations managers	44,197	1,086	9,896	\$107,271	\$45,133	\$67,357	\$166,721	\$247,434
9. Sales representatives, services, all other	27,221	669	25	\$55,565	\$26,507	\$37,861	\$82,210	\$123,307
10. Industrial engineers	3,402	84	24	\$93,097	\$56,632	\$71,896	\$117,565	\$142,439

Notes: The number of available applicants is a point-in-time measurement of the number of people who have registered in Colorado's workforce development system's statewide database, Connecting Colorado, as being able and available to work in a particular occupation. Results should be interpreted with caution since registration in Connecting Colorado is self-reported. In addition, the skills rubric may assign up to four occupation codes for each registrant. Therefore, the number of available applicants could be inflated. Source: Provided by Arapahoe/Douglas Works!; OCEW Employees, Non-OCEW Employees, & Self Employed - EMSI 2017.3 Class of Worker.

Education & Training

Colorado's higher education system provides an excellent support system for businesses in the state. There are 28 public higher education institutions in Colorado, consisting of 13 four-year and 15 two-year public institutions offering comprehensive curricula. There are more than 100 private and religious accredited institutions and more than 350 private occupational and technical schools offering courses in dozens of program areas throughout the state. The state higher education system served about 255,510 students in

AEROSPACE: Colorado Industry Cluster Profile

FY 2015-16, while 86,070 students received a degree, diploma, certificate, or other formal award over the same period of time. Although not exhaustive, a list of the major, accredited educational institutions with the greatest number of graduates for each of the 10 largest aerospace occupations in Colorado are included below. A directory of all higher education institutions with corresponding websites may be accessed via <http://higher.ed.colorado.gov>.

- Colorado School of Mines
www.mines.edu
- Colorado State University
www.colostate.edu
- Colorado State University Global Campus
www.colostate.edu
- Metropolitan State University of Denver
www.msudenver.edu
- Regis University
www.regis.edu
- U.S. Air Force Academy
www.usafa.af.mil
- University of Colorado: Boulder, Colorado Springs, Denver
www.cu.edu
- University of Denver
www.du.edu
- University of Northern Colorado
www.unco.edu

2017 INDUSTRY HIGHLIGHTS

Key Company Announcements

- Construction is underway on **Lockheed Martin Space System Co.'s** (LMSS) new \$350 million Gateway Center facility that will produce next-generation satellites at its Waterton Canyon campus in Jefferson County. The new 266,000-square-foot facility will include a clean room and two testing chambers, and is slated for completion in 2020. LMSS has added more than 750 local jobs since 2014 and has invested \$250 million in construction and facilities at its headquarters.
- **Lockheed Martin Autonomous Systems**, the center for the company's development of technologies for self-driving ground transportation, autonomous drones, machine learning, and machine vision, expanded its Littleton footprint. The new space will provide more room to test fly autonomous drones with potential to accommodate more than 100 workers.
- LMSS will move 650 jobs from California to Colorado and Florida after receiving a major contract to expand work on the submarine-launched Trident II D5 nuclear missile for the U.S. and British Navies. The engineering and design positions will be added over the next eight years.
- **Sierra Nevada Corp.** leased 101,000 square feet of additional industrial space at the Colorado Technology Center in Louisville and intends to add 400 workers in the next 18 months.
- **Sierra Completions**, a subsidiary of Sierra Nevada Corp., won a FAA repair-station license to begin turning wide body aircraft into flying offices for high-end customers and will hire 200 employees. The company opened a 60,000-square-foot, \$11 million hangar at Colorado Springs Airport to complete maintenance and alterations on military and civilian aircraft. Sierra built a 30,000-square-foot hangar in 2015 and is leasing a former air-freight terminal on an adjacent site used by Sierra Completions until construction is completed over the next five years on its \$100 million Colorado Aerospace Park.
- **Ball Corp.** will add 145,000 square feet and 300 workers to its existing Aerospace Manufacturing Center in Westminster, with completion expected in 2019. The expansion will support ongoing customer demand and projected growth.
- **Trimble Inc.** began construction on a second 120,000-square-foot building in Westminster, which is slated for completion in late 2018. With the capacity to accommodate more than 1,100 workers, the campus will be Trimble's largest employment center and will continue to serve as a central business hub for several of the company's core market segments, including geospatial.
- **Special Aerospace Services** opened a new 25,000-square-foot automated machining and specialized manufacturing facility in Arvada. The firm plans to expand manufacturing activities and will more than double its workforce to 30 people in the next two years.
- **Tendeg LLC** will move within the Colorado Technology Center in Louisville to a new 7,349-square-foot building. The aerospace engineering firm provides design, analysis, prototyping, and flight-unit assembly.
- Golden-based **NFT Inc.** relocated its headquarters to a 53,656-square-foot industrial building at the Colorado Technology Center. The move more than doubled the company's nuclear, aerospace, and automation manufacturing and office space.
- Vancouver, Canada-based **MacDonald Dettwiler and Associates** completed its \$2.4 billion purchase of Westminster-based **DigitalGlobe** and will rebrand the combined company as Maxar Technologies.

The new company will serve as a leader in satellite systems, earth imagery, geospatial solutions, and analytics, and offers a broader set of space-based solutions, increased scale, and a more diversified revenue base.

Colorado is a growing hub for high-growth space startups and space entrepreneurs as a result of new technologies, affordable small satellites, big data technologies, and increasing venture capital.

- Longmont-based **Roccor Inc.** partnered with the Air Force Research Laboratory (AFRL) to license its high strain component technology. Under the agreement, Roccor will deploy 1,800 solar arrays that will be secured to AFRL's 900-satellite fleet. The company has expanded to 40 people with plans to hire additional staff as it readies for full-scale production in 2018.
- NASA selected space startup Boulder-based **Altius Space Machines** for an SBIR Phase II contract to develop a cryogenic propellant transfer coupling for in-space refueling. The technology has numerous space applications since existing designs are not capable of in-space refuelability.
- Denver-based **BridgeSat, Inc.** and **AstroTerrace, Inc.** were awarded a contract to support the development of the optical communications system on the Japanese Government's Engineering Test Satellite 9 (ETS-IX). The company's optical communications ground network aims to improve the transfer of data from satellites, which could deliver data rates of 10 Gbps when ETS-IX launches in 2021.

Research and Education Announcements

- **Lockheed Martin** will donate \$1 million to **Metropolitan State University of Denver** (MSU Denver) over the next four years to support advanced manufacturing instruction and laboratories at the school's new Aerospace and Engineering Sciences Building. The funding will provide a new Lockheed Martin Additive Manufacturing Laboratory, where students can use state-of-the-art computer-controlled machines and 3D printing technology to design and create aerospace components. Other industry partners include PADT and Stratasys Ltd.
- **York Space Systems** partnered with **MSU Denver** to move its headquarters and establish a new manufacturing facility and Mission Operations Center at the new Aerospace and Engineering Sciences building. The company plans to add staff to begin production for up to 200 satellites per year.
- **EyasSat, Inc.**, a manufacturer of desktop satellite kits for teaching spacecraft systems engineering, will relocate its headquarters to **MSU Denver's** Aerospace and Engineering Sciences building in early 2018.
- The **University of Colorado Boulder** (CU Boulder) broke ground on an \$82.5 million, 144,000-square-foot aerospace engineering building, which is slated for completion in mid-2019. The facility will house an indoor flight environment for unmanned aircraft, a 200-seat auditorium, distance learning-equipped classrooms, faculty offices, and spaces for graduate students.
- Sixteen payloads from K-12 schools and educational organizations throughout Colorado flew on Centennial-based **United Launch Alliance's** Future Heavy intern rocket, the world's largest high-powered sport rocket. The 53-foot-tall, high-power sport rocket launch took place at Spaceport America, N.M. during its annual Spaceport America Cup International Intercollegiate Rocket Engineering Competition.
- A consortium of universities, led by **CU Boulder's** Ann and H.J. Smead Department of Aerospace Engineering Services, received a five-year, \$7.5 million DoD grant to investigate the extreme altitudes—between 80,000 feet and 120,000 feet—where hypersonic planes would fly. The Department will launch a series of high-altitude balloons carrying instruments to record atmospheric conditions.
- Longmont-based **Blackfox Training** partnered with **Lockheed Martin** to create a first-of-its-kind program to train veterans with skills and certifications in critical electronics assembly work for a career path in the aerospace and defense industry.
- Aerospace and defense incubator, accelerator, and research and development center—**Catalyst Campus for Technology and Innovation**—will launch the Catalyst Accelerator at its Colorado Springs campus in January 2018. The Catalyst Accelerator aims to promote technology advancement for the warfighter and guide technology transfer from the government to the commercial market and vice versa. The accelerator will provide a mentor-driven curriculum for accelerator teams.

CU Boulder solidified several research agreements with private aerospace partners in 2017.

- Bolstering its 60-year collaboration with **Ball Aerospace**, CU Boulder unveiled a new five-year, master university research agreement. The agreement will facilitate and streamline opportunities for students and faculty to work with Ball to conduct sponsored research.
- CU Boulder and **Harris Corporation** partnered under a new three-year master research agreement that will further mutual interests in analytical instrumentation, space antennas, space payloads and electronics, radar, universe exploration, and other capabilities. The agreement will initiate and expand upon projects and collaborative opportunities.
- **Lockheed Martin** will expand its research collaboration with CU Boulder with a master research agreement. The new agreement builds on the company's \$3 million funding of the Lockheed Martin Radio Frequency Space Systems Research Center at CU Boulder, and includes four new projects totaling \$675,000.
- CU Boulder's Department of Astrophysical and Planetary Sciences research team and **NASA** partnered under a five-year, \$4.5 million cooperative agreement to join its Solar System Exploration Research Virtual Institute to pursue construction of astronomical observatories on the moon.

2017 INDUSTRY MILESTONES

Colorado is leading the nation's major aerospace missions and projects. Three Colorado-based projects were named to *Popular Science's* 2017 Top 10 Most Incredible Aerospace Inventions: OSIRIS-REx, the GOES weather satellite, and Dream Chaser. These and other examples of collaborative projects and their progress are highlighted below.

Dream Chaser®

Louisville-based Sierra Nevada Corporation's (SNC) Space Systems is developing the Dream Chaser spacecraft through significant collaboration with other Colorado-based aerospace companies. The Dream Chaser is a winged, lifting-body spacecraft designed for both crewed and uncrewed missions to low Earth orbit (LEO) including cargo resupply to the International Space Station (ISS) for the National Aeronautics and Space Administration (NASA), as well as international and commercial space missions for at least six missions through 2024. SNC is also evaluating international and commercial space opportunities. Several milestones were reached in 2017:

- SNC successfully conducted its Approach and Landing Test 2 (ALT-2) flight in late 2017. The free-flight test allowed the spacecraft to fly under its own systems and automated guidance. The ALT-2 flight followed several successful Captive Carry and tow tests earlier in the year.
- SNC passed the third integration milestone in May, which confirmed the cargo system design met NASA's key requirements and maximized probability of mission success during future flights. The spacecraft also successfully demonstrated safety and mission assurance criteria.
- United Launch Alliance's (ULA) Atlas V rocket was selected to launch SNC's first two resupply missions to the ISS, which are scheduled to launch in 2020 and 2021. SNC's Dream Chaser Cargo System will provide up to 5,500 kilograms of upmass, as well as both return and disposal services.

Global Positioning System (GPS)

Lockheed Martin Space Systems (LMSS) is developing the U.S. Air Force's (USAF) next generation of Global Positioning System (GPS III) satellites—the newest military and civilian navigation technology that delivers three times better accuracy, provides up to eight times improved anti-jamming capabilities, and includes enhancements which extend spacecraft life 25 percent longer than the prior GPS block. Lockheed has 10 GPS III satellites in full production phase at its GPS III Processing Facility in Jefferson County.

- The USAF has declared the first GPS III satellite ready for launch, and Lockheed plans to begin pre-launch preparations ahead of the satellite's expected launch in 2018. Integration on the second GPS III satellite is complete, and after environmental testing is expected to be delivered to the USAF in 2018.
- Lockheed has also completed assembly of its third GPS III satellite, which is being prepared to begin environmental testing.

GOES-R

LMSS is developing the next-generation geostationary weather satellites, the Geostationary Operation Environmental Satellite-R Series (GOES-R), which includes GOES-R (launched in November 2016), GOES-S, GOES-T, and GOES-U. The next satellite in the series, GOES-S is fully integrated, finished with environmental

and mechanical testing, and preparing for launch in the spring of 2018. The primary subassemblies of the GOES-T satellite are underway in Jefferson County, with the launch slated for 2020. The GOES satellites provide accurate, real-time weather forecasts and early warning products to the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service and other public and private sectors.

GPS OCX

Raytheon delivered the first portion of the GPS Operational Control System (OCX) to the USAF Space and Missile Systems Center. Block 0 is a significant program milestone, as it provides the USAF with a cyber-hardened ground system to support the launch and on-orbit checkout of the GPS III satellites, and provides the hardware, software, and cybersecurity base for Block 1. Block 1 and 2 are slated for delivery in 2022. OCX will provide command and control of new capabilities associated with the new GPS III family of satellites as well as legacy satellites and all new civil and military signals.

The Imaging X-ray Polarimetry Explorer (IXPE) Mission

Ball Aerospace will provide the spacecraft and mission integration and CU Boulder's Laboratory for Atmospheric and Space Physics will perform mission operations for NASA's Imaging X-Ray Polarimetry Explorer (IXPE) Mission. Scheduled to launch in 2021, the mission will allow astronomers to explore the hidden details of some of the most extreme and exotic astronomical objects, such as supermassive black holes, neutron stars, and pulsars, helping scientists to better understand the origin of the universe. The mission is led by NASA's Marshall Space Flight Center in Huntsville, Ala.

InSight

LMSS built the Mars lander spacecraft for NASA's InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) mission. InSight is a NASA Discovery-class mission to understand the processes that shaped rocky planets such as Mars and Earth. Scheduled to launch in May 2018, a Lockheed Martin team will operate the spacecraft on its seven-month journey to Mars, its landing, and during surface operations. In 2017, the lander and the environmental testing phase were successfully completed.

Joint Polar-Orbiting Satellite System

JPSS-1, built and designed by Ball Aerospace, launched in November 2017. JPSS is the next generation of polar-orbiting environmental satellites and is a cooperative program between NOAA and NASA. Ball also integrated all five of the spacecraft's instruments and is performing satellite-level testing and launch support. Raytheon built the JPSS Common Ground System, which provides command, control, communications, data processing, and product delivery.

Mars 2020

NASA's Mars 2020 mission will be launched by ULA in 2020, with the Mars rover scheduled to land in 2021 for a two-year exploration of the Martian surface. LMSS will build the aeroshell and heat shield which will protect the rover during its journey to Mars and descent to the planet's surface. SNC's Space Systems will build critical hardware for the rover, including the descent brake and actuators for the robotic arm and sample cache system.

NextSTEP-2

SNC and LMSS began construction on design ground prototypes and concepts for deep space habitats on Mars, as part of NASA's Next Space Technologies Exploration Partnership-2 (NextSTEP-2), a program to produce habitats that could support astronauts working and living outside Earth's orbit. Work under the Phase II contract will take place over 18 months.

Orion

LMSS is building the Orion Multi-Purpose Crew Vehicle, NASA's first spacecraft designed to transport humans to destinations beyond LEO, such as the moon, asteroids, and eventually Mars, as early as 2023. Lockheed Martin's new Orion Test Lab is the first testing facility of its kind for a NASA human-rated spacecraft built on a contractor's campus. Following Orion's highly successful, first high orbital test in 2014, the spacecraft's next flight will be Exploration Mission-1, projected to launch in 2019 on NASA's new Space Launch system rocket. Orion was successfully powered-on in 2017, the first step in testing the crew module subsystems, and engineers and technicians will continue integrating the spacecraft's 55 components.

OSIRIS-REx

LMSS built NASA's OSIRIS-REx spacecraft, which is an asteroid sample return mission. Launched in 2016, the Origins Spectral Interpretation Resource Identification Security-Regolith Explorer will study and return a sample of carbonaceous asteroid to Earth for detailed analysis in 2023.

Space-based Missions

- NASA selected a space probe named Lucy, proposed by the Boulder office of the Southwest Research Institute, for its next Discovery-class mission. The 12-year mission will launch in October 2021 to study six asteroids near Jupiter to further scientific understanding of the early solar system. LMSS will build, assemble, and test the spacecraft.
- NASA tripled the number of flights awarded to SpaceX and Boeing Co., giving ULA four additional missions to ferry astronauts to the ISS. In 2018, Boeing's CST-100 Starliner, capable of carrying up to four astronauts and 220 pounds of cargo, will launch aboard an Atlas V rocket.
- NASA's Launch Services Program selected ULA's Atlas V rocket to launch the Landsat 9 mission, the ninth in a satellite program which has provided the longest continuous global record of Earth's surface. The Landsat 9 mission could launch as early as December 2020.
- ULA partnered with Nevada-based Bigelow Aerospace to develop and deploy experimental, inflatable space habitats by 2022 to function as a depot for lunar missions. A Bigelow test habitat has been attached to the ISS for 18 months.
- Ball Aerospace was selected to design and build a cryostat for NASA's Galactic/Extragalactic Ultralong Duration Balloon Spectroscopic Terahertz Observatory (GUSTO) mission in 2021. The mission will study dust and material from exploding stars, which will assist researchers in understanding the lifecycle of stars in the Milky Way Galaxy.
- ULA received a contract to launch Pittsburgh-based Astrobotic Technology Inc.'s Peregrine Lunar lander to the moon in 2019, during the 50th anniversary of Apollo 11. Astrobotic has signed 11 contracts with customers who want to participate in its first flight that will carry payloads to the lunar surface.

Defense-based Missions

- Colorado Springs-based Boecore won a \$93 million USAF contract to provide early-warning information of ballistic missile launches. The work will be performed at Peterson Air Force Base, which is slated for completion by June 2022. The award is part of the Shared Early Warning System (SEWS II) Engineering and Contractor Logistics Support program.
- ULA successfully deployed three payloads on behalf of the U.S. National Reconnaissance Office. NROL-79, NROL-52, and NROL-42 spy satellites will support national security efforts.
- Denver-based York Space Systems was awarded a military contract with the U.S. Army Space and Missile Defense Command to produce a small satellite for the Harbinger Mission planned to launch in late 2017.

Satellite Programs

- CU Boulder's Laboratory for Atmospheric and Space Physics (LASP) successfully installed its Global-Scale Observations of the Limb and Disk (GOLD) onto the SES-14 commercial communications satellite. NASA is providing LASP with \$36 million for designing, building, and operating the GOLD instrument for the mission, which will capture unprecedented imaging and data of the Earth's upper atmosphere.
- NASA awarded Ball Aerospace the five-year Suomi National Polar-Orbiting Partnership Sustainability (SNPPS) contract. Under this contract, Ball Aerospace will continue to provide sustaining engineering services to the JPSS Flight Project and NOAA's Office of Satellite and Product Operations for the mission operations systems and subsystems, and deactivation of the Suomi NPP satellite.
- ULA launched the USAF's Wideband Global SATCOM-8 (WGS) satellite aboard a Delta IV rocket. Two additional WGS satellites are in production, bringing the total constellation to 10 by 2019. The satellite was the eighth WGS satellite launched by ULA since 2007.
- ULA was awarded a \$191.1 million USAF contract to launch the Space Test Program-3 (STP-3) mission. STP-3 is an experimental blast-detection satellite, which is scheduled to launch in mid-2019.
- Ball Aerospace completed a six-month Phase A study of the scientific and technology requirements for the Wide Field Survey Telescope (WFIRST) project's Wide Field Instrument. WFIRST will be NASA's next flagship space telescope under development and will follow NASA's James Webb Space

Telescope. WFIRST captures individual images with the depth and quality of the Hubble Space Telescope, while covering 100 times the area.

- Douglas County-based EchoStar Corp. launched its 105/SES-11 and XXIII communication satellites into orbit that will provide increased capabilities and expanded reach. The 105/SES-11 will provide Ku-band transponder capacity media distribution over North America and the Caribbean, while the XXIII will provide broadcast services for Brazil.
- Maxar Technologies selected Raytheon as the payload provider for its WorldView Legion constellation of next-generation satellites to capture Earth imagery in 2020. The payload will supersede WorldView-1 and 2—which launched in 2007—and will increase Maxar’s capacity to record multispectral and 30-centimeter satellite imagery on high-demand locations.
- The Tropospheric Emissions: Monitoring of Pollution (TEMPO) instrument, designed and built by Ball Aerospace for NASA, has completed spectrometer testing and verification. TEMPO was selected by NASA as the first Earth Venture-Instrument to provide hourly measurements of air quality across North America.
- CU Boulder designed and built NASA’s Total and Spectral Solar Irradiance Sensor (TSIS-1) to help monitor the planet’s climate, which launched in 2017. The \$90 million solar instrument suite and associated mission ground system will measure the sun’s energy input to Earth.
- NOAA and the USAF will launch the first six satellites of the Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC-2S) constellation, to support improved numerical weather prediction model forecasts. The research that made this operational constellation possible was conducted by Boulder-based University Corporation for Atmospheric Research (UCAR).

Several instruments and satellites were launched to the ISS:

- Ball Aerospace’s Boulder-built Stratospheric Aerosol and Gas Experiment III (SAGE III) launched in February 2017. SAGE III will be used for environment observations, and the Vision Navigation Sensor for technical operations.
- ULA launched a mission aboard its Atlas V rocket, carrying supplies and science experiments to the ISS. The mission was the third time ULA launched Cygnus for an ISS supply run and was the first time the company used RapidLaunch to increase mission delivery speed.
- ULA launched NASA’s Tracking and Data Relay Satellite-M (TDRS-M) on an Atlas V rocket to track phone calls and data traffic for the ISS. The TDRS-M satellite is the third generation of the orbiters to be launched, and the last of three built by Boeing Space Systems under a NASA contract awarded in 2007.
- Two CU Boulder-built payloads launched, including one to examine changes in cardiovascular stem cells in microgravity and one to study novel treatments for bone loss in space. The two biomedical research payloads were developed by BioServe Space Technologies, which is also launching its third Space Automated Bioproduct Lab unit to the ISS.

Spaceport Colorado

In 2017, Front Range Airport continued the application process for certification from the FAA to operate as a horizontal-launch spaceport facility. The subsequent designation for Spaceport Colorado, which may be granted in 2018, fulfills a 2011 declaration by Gov. John Hickenlooper of Colorado’s intent to become a spaceport state. The effort will increase Colorado’s competitiveness in the aerospace industry and support new opportunities in the future growth of commercial space research and transportation. Plans for Spaceport Colorado include the development of an aerospace and technology park to support a broad range of activities and commercial opportunities, including research and development, testing and evaluation, manufacturing, crew training, scientific research, suborbital flight, and point-to-point travel. Spaceport Colorado has an abundance of surrounding land and convenient access to Denver International Airport and the state’s sizeable aerospace industry, research universities, and talented aerospace workforce.

Industry Infrastructure Support



The Colorado Space Coalition (CSC), a group of industry stakeholders, works to promote Colorado as a leader in the aerospace industry. Coalition members—including aerospace companies, military leaders, academic groups, and economic development organizations—promote Colorado’s significant aerospace assets nationally and advance legislation vital to industry growth and success.



The Colorado Space Business Roundtable (CSBR) is an independent, nonprofit organization promoting the growth of space and space-related industry in Colorado, with particular focus on small space businesses. CSBR members include a broad cross-section of the Colorado space community that support the space industry with services, advocacy, and procurement.



The Colorado Chapter of the Aerospace States Association is comprised of the CSC, the CSBR, and the Colorado Chapter of Citizens for Space Exploration. The partnership collaborates on industry events, outreach, and advocacy efforts.



The Space Foundation is a Colorado Springs-based organization that supports all sectors of the space community across the globe. Founded in 1983, the Space Foundation is a leader in space activities, educational support, major space events, and space research and development. The Space Foundation also hosts the annual Space Symposium, the premier gathering of the global space community.



The Colorado Chapter for Citizens for Space Exploration comprises private citizens, small business owners, students, teachers, space and non-space business representatives, and county and municipal officials. The Chapter actively promotes awareness of the benefits of America’s Human Space Exploration Program and support for NASA.



The American Institute of Aeronautics & Astronautics (AIAA) Rocky Mountain Section represents aerospace technical professionals, students, and educators in Colorado, Wyoming, and Montana. Members advance innovation and technical excellence through monthly programs, university chapters, policy advocacy, public outreach, STEM education, technical committees, and professional development.

Key Reasons for Aerospace Companies to Locate in Colorado

Colorado is a top aerospace location offering:

1. The ability to recruit and retain technical and scientific employees and entrepreneurial talent

- Nearly 40 percent of Coloradans have at least a bachelor's degree, the second-highest college attainment rate in the nation behind Massachusetts. (U.S. Census Bureau, 2016 American Community Survey)
- Established in 2014, the U.S. Department of Commerce U.S. Patent and Trademark Rocky Mountain Regional Office in Denver expedites patent examination in the region, advances cutting-edge ideas to the marketplace, empowers entrepreneurs, and creates new highly-skilled jobs. (U.S. Patent and Trademark Office, 2017)
- Colorado ranked eighth in the nation for entrepreneurship growth, with a 74.1 percent rate of startup growth, 1.3 percent share of scaleups, and 96.9 percent high-growth company density. (Ewing Marion Kauffman Foundation, 2017)
- Colorado ranked No. 2 for the "Best States for Jobs" in 2017 and ranked first nationally for job opportunities. (WalletHub, 2017)

Colorado has the second-highest college attainment rate in the nation.

—U.S. Census Bureau, 2016

2. Proximity to vendors and customers

- Colorado ranked No. 3 in National Aeronautics and Space Administration (NASA) prime contract awards totaling \$1.8 billion in 2016, or 13 percent of the nation's total. (NASA, 2017)
- Colorado's aerospace cluster is anchored by eight large prime contractors: Ball Aerospace, The Boeing Company, Harris Corporation, Lockheed Martin, Northrop Grumman, Raytheon, Sierra Nevada Corporation, and United Launch Alliance.
- Colorado is a host to major military operations including Buckley AFB, Peterson AFB, Schriever AFB, and Cheyenne Mountain Air Force Station. In addition, the U.S. Air Force Academy is located just outside of Colorado Springs.
- Cheyenne Mountain Complex serves as NORAD and USNORTHCOM's Alternate Command Center and as a training site for crew qualification.
- Colorado's Procurement Technical Assistance Centers (PTAC) provide expert procurement guidance at nominal or no cost to any Colorado business. PTAC has over 3,000 active clients that received nearly 730 government contract awards totaling \$216.5 million.

Colorado ranked No. 3 in NASA prime contract awards in 2016.

—National Aeronautics and Space Administration (NASA), 2017

3. Business organizations and public policy programs designed to encourage industry growth

- Maj. Gen. Jay Lindell was appointed in 2013 by Gov. Hickenlooper as Colorado's Aerospace and Defense Industry Champion to oversee implementation of the state's aerospace strategic plan and assist aerospace businesses, defense installations, and research institutions.
- Aerospace Day at the Colorado Capitol occurs annually to recognize the industry's importance to the state's economic growth. Formed in 2015, the state's bipartisan Aerospace and Defense Caucus further supports the continued expansion of aerospace and defense in Colorado.
- The Advanced Industries Accelerator Programs include four types of grants and a global business support program to promote growth and sustainability in Colorado's advanced industries, including aerospace, among others. The program has awarded over \$40 million in grants since its inception in 2013. (Colorado Office of Economic Development and International Trade, 2017)
- Personal property used in an orbital space facility, a space propulsion system, satellite, or space station is exempt from sales and use taxes. The exemption encourages capital investment in aerospace manufacturing suppliers. (Exemption clarified in Colorado House Bill 14-1178)
- To further pave the way for Spaceport Colorado, legislation passed in 2012 will help expand the state's aerospace economy by limiting liability for public and private entities holding a Federal Aviation Administration license for spaceflight activities. (See Senate Bill 12-035 for more information)

4. Proximity to colleges/universities

- Two academic institutions in Colorado offer nationally ranked aerospace programs or degrees:
 - The University of Colorado Boulder's aerospace engineering sciences graduate program ranked

CU Boulder's aerospace engineering sciences graduate program ranked among the top 10.

—U.S. News & World Report, 2017

among the top four programs in the nation by the National Research Council and among the top 10 by *U.S. News & World Report* in 2017. (National Research Council, 2010; *U.S. News & World Report*, 2017)

- The U.S. Air Force Academy in Colorado Springs ranked second in the nation for an undergraduate aerospace engineering program where a doctoral degree is not offered. (*U.S. News & World Report*, 2017)
- The U.S. Air Force Academy (seventh) and the Colorado School of Mines (19th) ranked among the "Top 25 Science, Technology, Engineering, and Mathematics Colleges of 2017." (*Forbes*, 2017)
- CU Boulder's Laboratory for Atmospheric and Space Physics is a full-cycle space institute and is the only university-based institution in the world to have designed and built space instruments for NASA that have been launched to all eight planets and Pluto.
- CU Boulder ranked among the top five U.S. universities, excluding military academies, in the number of astronaut alumni and is one of the top NASA-funded universities in the world. (University of Colorado, 2017)
- CU Boulder receives \$120 million in aerospace-related research annually and is home to over a dozen aerospace-related departments, centers, and institutes. (University of Colorado, 2017)
- Colorado has the largest portfolio of research supported by the National Science Foundation's Geosciences Division, with more than \$1.4 billion in active awards. (National Science Foundation, 2017)

5. Low to moderate costs of doing business

- Colorado ranks as one of the nation's most favorable corporate income tax structures. The state's corporate income tax rate of 4.63 percent is one of the lowest in the nation and is based on single-factor apportionment, which allows companies to pay taxes based solely on their sales in the state. (State of Colorado; The Tax Foundation)
- Colorado ranks as the nation's 10th-best tax system for entrepreneurs and small business. (Small Business & Entrepreneurship Council, 2017)

6. Pro-business and flexible state and local governments

- Colorado ranked No. 8 for attractiveness to the aerospace manufacturing industry. The state ranked No. 2 for tax policy, No. 3 for labor, and No. 7 for infrastructure. (PricewaterhouseCoopers, 2017)
- Colorado ranked No. 8 among *Forbes'* 2017 "Best States for Business" list. The state received its highest rankings for labor supply (first overall), economic climate (third overall), and growth prospects (fourth overall). (*Forbes*, 2017)

Colorado ranked No. 6 among the top states for business.

—CNBC, 2017

- Colorado ranked fourth in the nation for Small Business Innovation Research (SBIR) grants per worker. The state received \$32.90 in grants per worker compared with the U.S. average of \$13.34. (U.S. Small Business Administration, 2017; U.S. Bureau of Labor Statistics, 2017)

• *CNBC* ranked Colorado No. 6 on the list of "America's Top States for Business" in 2017. The state ranked among the top-10 in the categories that measure workforce (fourth), technology and innovation (seventh), and business friendliness (eighth). (*CNBC*, 2017)



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